Geology and mineral occurrences of the mineral districts of Hidalgo County, southern New Mexico

Virginia T. McLemore and Wolf E. Elston, 2000, pp. 253-262

in:

Southwest Passage: A trip through the Phanerozoic, Lawton, T. F.; McMillan, N. J.; McLemore, V. T.; [eds.], New Mexico Geological Society 51 st Annual Fall Field Conference Guidebook, 282 p.

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GEOLOGY AND MINERAL OCCURRENCES OF THE MINERAL DISTRICTS OF HIDALGO COUNTY, SOUTHERN NEW MEXICO

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Abstract—Value of metallic mineral production from 15 districts in Hidalgo County is estimated as $65 million during 1875–1994 (not including the Hidalgo smelter output or aggregate production). The majority of past metal production came from the Lordsburg district, which is the 5th largest gold-producing district and 3rd largest silver-producing district in New Mexico. Deposit types found in the county include Laramide polymetallic veins, skarns, and carbonate-hosted Pb-Zn replacements, as well as epithermal manganese, volcanic-epithermal vein, porphyry copper, and placer gold deposits. Only aggregates are being mined in the county currently.

INTRODUCTION

This paper presents a summary of the mineral resources, excluding aggregate resources, in Hidalgo County (Table 1). North and McLemore (1986), Cox and Singer, (1986), Bartsch-Winkler (1997), and McLemore (*in press*) described the deposit types. The geology and stratigraphy of the districts are described elsewhere in this volume and in cited references. District maps with more detail and location of mines and prospects can be found in McLemore et al. (1996b) and other cited reports. Metal production since the late 1800s is listed by district in Table 2. Mining and production records are generally poor, particularly for the earliest times and many early records are conflicting. These production figures are the best data available and were obtained from published and unpublished sources (New Mexico Bureau of Mines and Mineral Resources, NMBMMR file data). However, production figures are subject to change as new data are obtained.

Hidalgo County (Fig. 1) was established in 1919 from the southwestern part of Grant County (Julyan, 1996). Mining has been important to the economy of Hidalgo County, and until the 1960s, Hidalgo County typically ranked second (behind Grant County) in base- and precious-metal production in New Mexico. The Lordsburg district ranks 5th in gold and 3rd in silver production in New Mexico (McLemore, *in press*). McGhee Peak district ranks 8th and Lordsburg ranks 10th in lead and zinc production district in the state (McLemore and Lueth, 1995, 1996).

TABLE 1. Districts in Hidalgo County. Type of deposit after North and McLemore (1986), McLemore (*in press*) and includes USGS classification in parentheses (Cox and Singer, 1986).

DISTRICT (ALIASES)	YEAR OF DISCOVERY	YEARS OF PRODUCTION	COMMODITIES PRODUCED (PRESENT)	ESTIMATED CUMMULATIVE VALUE OF PRODUCTION (IN ORIGINAL DOLLARS)	TYPE OF DEPOSIT
Antelope Wells-Dog Mountains (Alamo Hueco)	?	none	Mn (U)	<100	epithermal manganese (25g)
Apache No. 2 (Anderson, Hachita)	late 1870s	1880–1956	Au, Ag, Cu, Pb, Zn, Bi (W, Ge, Be, Mo, F)	107,000	carbonate-hosted lead-zinc (19a), skarn (18a,19a), volcanic-epithermal (25b,c,d,e)
Big Hatchet Mts.	1917	1917, 1919	Ag, Pb, Zn (Cu)	2000	carbonate-hosted lead-zinc (19a)
Brockman	1900s	early 1900s–present	silica	<1,000,000(?)	sedimentary
Fremont (extends into Luna County, NM and Mexico)	1860	1880–1951	Cu, Pb, Zn, Au, Ag, U, V (Bi)	17,000	volcanic-epithermal (25b,c,d,e), carbonate-hosted lead-zinc (19a)
Gillespie (Red Hill)	1880	1905–1950	Au, Ag, Cu, Pb, F, Mn (W)	100,000	volcanic-epithermal (25b,c,d,e)
Granite Gap (San Simon)	1897	1897–1955	Cu, Pb, Zn, Au, Ag, W, Sb (Bi, Be, F, U, REE)	1,950,000	carbonate-hosted lead-zinc (19a), skarn (18a,19a)
Kimball (Steins Pass)	1875	1875–1953	Cu, Au, Ag, Pb, Zn	500,000	volcanic-epithermal (25b,c,d,e)
Lordsburg (Virginia, Pyramid, Ralston, Shakespeare)	1869	1885–1978, 1990–1994	Cu, Pb, Zn, Au, Ag, F, silica flux, aggrgate (Ge, Be, Mo, Ba)	>60,000,000	Laramide vein (22c), placer gold (39a)
McGhee Peak	1894	1894–1956	Cu, Pb, Zn, Au, Ag	<1,500,000	carbonate-hosted lead-zinc (19a), lead-zinc and copper skarns (18a, 19a), porphyry copper (21a)
Muir	?	1940s, 1952	F, Ag, (Pb, Cu, Au, Sb, Mn)	90,000–400,000	epithermal Mn (25g), fluorite veins (26b), volcanic-epithermal (25b,c,d,e)
Pratt	1902	1902–present	fire clay (F, Mn)	150,000–200,000	sedimentary
Rincon (Animas)	1880	1940–1949	Cu, Au, Ag, Pb (F, Mn)	320,000	carbonate-hosted lead-zinc (19a), epithermal manganese (25g), volcanic-epithhermal (25b,c,d,e)
Silver Tip (Bunk Robinson, Whitmore, Cottonwood Basin)	1930	none	(Au, Ag, Pb, Mo, Zn, Bi, Ba, F)	—	volcanic-epithermal (25b,c,d,e)
Sylvanite	1871	1902–1957	Cu, Pb, Au, Ag, W, As (Sb, Te, Zn, Ge, Be, Mo, Bi, Ba, F)	315,000	lead-zinc and copper skarns (18a, 19a), Laramide vein (22c), placer gold (39a)

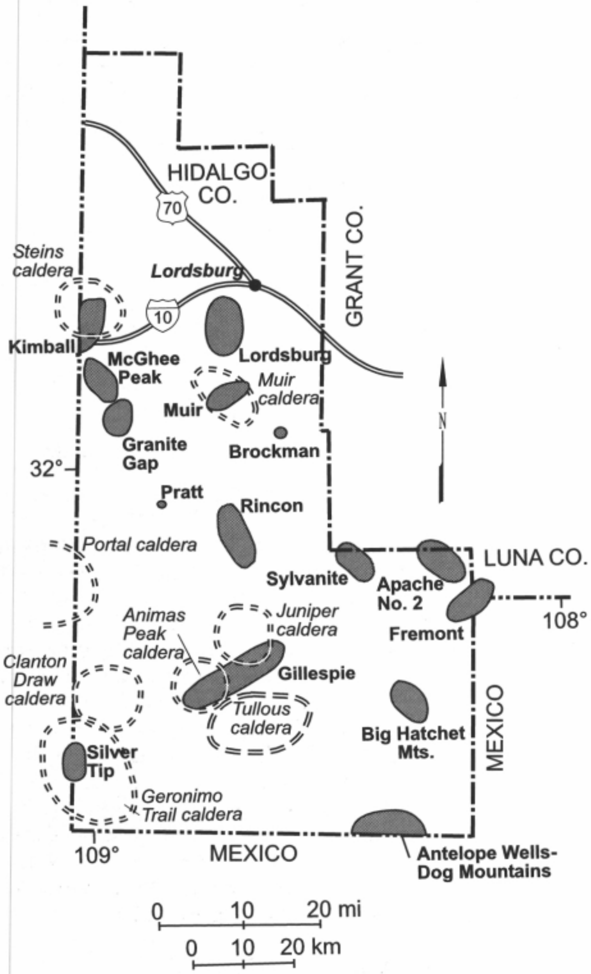

FIGURE 1—Districts in Hidalgo County, New Mexico.

Prospecting in the county began about 1869, but no serious production occurred until arrival of the railroad in Lordsburg in 1880. With the demonetization of silver in 1893, emphasis shifted to base-metal production and continued until the general decline of underground mining in the 1980s. Total mineral production from 1880 to 1994 exceeded $65 million, at prices prevailing at the time of mining (Table 1; Elston, 1963, 1965; McLemore et. al., 1996b). Recent production included silica sand and clay for use as smelter flux (Little Hatchet, Brockman and Pratt mines) and sand and gravel as aggregate. Copper-gold veins were mined in the Lordsburg district for silica flux in 1990–1994 (White, this volume). The Hidalgo (or Playas) smelter in the Animas Valley was built in 1976, produced copper, silver, gold, and sulfuric acid from concentrates shipped from Morenci, Chino, and other porphyry copper mines, and closed in September 1999 (Gundiler, this volume, p. 263).

ANTELOPE WELLS-DOG MOUNTAINS DISTRICT

Epithermal veins of manganese and uranium, travertine, and cave deposits of guano are widespread in the Antelope Wells-Dog Mountains district in the Alamo Hueco, White, and Dog Mountains along the New Mexico-Mexico border (Fig. 1). The area contains layered mid-Tertiary (35–27 Ma) volcanic rocks and sedimentary rocks (Zeller, 1958; Zeller and Alper, 1965; Deal et al., 1978; Reiter, 1980; Bryan, 1995). Ash-flow tuffs in the area are outflow sheets, erupted from calderas in the Animas and Peloncillo Mountains (Fig. 1; Bryan, 1995; McIntosh and Bryan, this volume). Northwest- to north-northwest-trending faults have intensely broken the ranges.

At the Opportunity claims (SE¼ sec. 15, T34S, R15W), radioactive quartz-opal veins (1 cm thick) surround angular clasts of the Oak Creek and Gillespie Tuffs at the intersection of east- and northwest-trending faults (Everhart, 1957; McLemore, 1982, 1983). Mineralized breccia was traced for 137–183 m northwest from two 3-m-deep pits where opal and quartz veins reached approximately 20 cm thick. Samples assayed 0.02–0.77% U_3O_8 (McLemore, 1982, 1983), but milling tests on approximately 2 short tons (st) of ore shipped in 1954 failed to separate the uranium from the opal and quartz (Everhart, 1957; Reiter, 1980; A. E. Mittle, personal commun., 1959).

Extensive travertine deposits, with banded manganese up to 20 cm wide, occur in the Bluff Creek Canyon Formation in sec. 8, T34S, R17W (Reiter, 1980). In 1954, T. C. Boyles shipped 5.6 long tons (lt) of 37.9% Mn from the Rusty Ruthlee mine to Deming (Farnham, 1961). Bat guano is found in a cave in the U-Bar Formation in sec. 16, T33S, R14W (Reiter, 1980).

APACHE NO. 2 DISTRICT

The Apache No. 2 (Anderson, Hachita) district, in the Apache Hills, was discovered in the late 1870s (Fig. 1). From 1880 to 1956, the district produced 1.3 million lbs Cu, 300,000 lbs Pb, and some Ag, Au, Zn, and Bi (Table 2; Lasky and Wootton, 1933; Elston, 1965; McLemore et. al., 1996b). In the Apache Hills, Cretaceous sedimentary rocks and Paleozoic limestone (Strongin, 1957; Peterson, 1976) are overlain by mid-Tertiary volcanic rocks, mainly the Gillespie (32.7 Ma; $^{40}Ar/^{39}Ar$, Bryan, 1995) and Oak Creek (33.5 Ma; $^{40}Ar/^{39}Ar$) Tuffs (formerly the Chapo Formation, Peterson, 1976), and intruded by the Apache quartz monzonite porphyry stock (27.18 ± 0.63 Ma, K-Ar, feldspar; Peterson, 1976; Deal et al., 1978) and irregular dikes and sills of monzonite porphyry. Propylitic and silicic alteration is pervasive.

Three types of deposits occur: skarns, carbonate-hosted Pb-Zn replacements and polymetallic veins (Table 1). The deposits extend into the Sierra Rica, Mexico, where a carbonate-hosted disseminated gold prospect in the U-Bar Limestone was explored in the late 1980s (M. L. Silberman, written commun., 1999). Three major mines, the Apache, Daisy, and Chapo, are in the United States. The Apache mine (NE¼ sec. 30, T28S, R14W) was first operated by Chihuahua Indians who carted ore to Chihuahua for smelting (Strongin, 1957). Robert Anderson operated the mine for a number of years starting in 1880. In the early days, silver ore (cerargyrite, galena, sphalerite) gave way to later production of oxidized pods of sulfides assaying 3–4% Cu, 1–1.4 ppm Au, and 205.7 ppm Ag that was shipped as a smelter flux. From 1915 to 1919, large quantities of Ag-Cu ore with bismuth in calcite gangue were shipped. From 1927 to 1929, a considerable tonnage of ore averaging 1.5% Cu and 650 ppm Ag was shipped. Additionally, several cars of ore were shipped from the Apache mine averaging 411 ppm Ag and 10% Pb. Since 1929, only small amounts of ore have been shipped.

The Apache ore body is an irregular skarn deposit controlled by major north-trending structures in Cretaceous limestone and is associated with the Apache stock (Lindgren et al., 1910). The most prominent of these structures is the McKinley fault, which is slightly mineralized with galena, sphalerite, and chalcopyrite and hosts the Apache deposit on its southeast side. Most of the material mined consisted of sulfide-filled fractures that contained few or no calc-silicate minerals. Veins containing andradite garnet, epidote, hematite, fluorite, and chalcopyrite occur locally. Ore minerals include galena, sphalerite, and associated cerargyrite in a gangue of calcite, garnet, limonite, and pyrite. Scheelite, cuproscheelite, and bismutite were identified in dump samples (Strongin, 1957). The richest ore shipped from the Apache mine contained 1.7 ppm Au, 435 ppm Ag, 21% Pb, 4% Cu, and 25% Zn (Elston, 1963). Dump and chip samples collected in the mid-1980s assayed as high as 1.3% Cu, 800 ppm Mo, 6.0% Pb, 0.2% Zn, and 174.8 ppm Ag (Peterson, 1976). Samples collected by Madison Enterprises of Vancouver, B.C., of the surface workings in the vicinity of the Apache mine in 1996–1997 contained as high as 1 ppm Au and 470 ppm Ag. Seventeen reverse-circulation holes were drilled, with negative results. The program was terminated in 1997. Elsewhere along the Apache fault additional Cu skarns are associated with monzonite and rhyolite dikes (Elston et al., 1979; Deal et al., 1978), predominant ore minerals include

TABLE 2—Base- and precious-metal production in Hidalgo County. ( ) = estimated production data from USGS (1902–1927) and USBM (1927–1990). USBM—U.S. Bureau of Mines. W = production not available. M = million. — = no production data.

DISTRICT	PERIOD OF PRODUCTION	ORE (ST)	COPPER (LBS)	GOLD (TROY OZ)	SILVER (TROY OZ)	LEAD (LBS)	ZINC (LBS)	REFERENCES	COMMENTS
Apache No. 2	1927–1956	5607	176,400	41	14,282	111,600	14,300	North and McLemore (1986)	$107,000 produced
	1880–1956	—	(1. 3 M)	(300)	(125,000)	(300,000)	(20,000)		(Elston, 1965)
Big Hatchet Mountains	1917, 1919	—	—	—	W	W	W	North and McLemore (1986)	$2000 produced (Elston, 1965)
Fremont	1880–1951	—	(2,000)	(10)	(10,000)	(190,000)	(4000)	North and McLemore (1986)	—
Gillespie	1908–1950	3746	3400	6	14,249	1,019,500	—	Elston (1965), North and	approximately
(Red Hill)	1880–1950	—	(5,000)	(20)	(20,000)	(1.8 M)	(2000)	McLemore (1986), USBM files	$100,000 produced
Granite Gap (San Simon)	1934–1955	16,906	20,400	303	91,052	1,606,750	652,200	Richter and Lawrence (1983)	approximately $1.95 million produced
Kimball (Steins Pass)	1875–1953	—	(12,000)	(1500)	(400,000)	(125,000)	W	North and McLemore (1986), USBM files	approximately $500,00 produced
Lordsburg	1885–1994	—	(229.577 M)	(286,275)	(8,067,741)	(11 M)	(4.2 M)	Richter and Lawrence (1983)	>$60 million produced
McGhee Peak	1894–1956	100,000	(85,000)	(100)	(200,000)	(12 M)	(10 M)	Gillerman (1958), Richter and Lawrence (1983)	—
Muir	1943–1948	(<100)	—	—	(<100)	—	—	Elston (1965)	$100 of metals
Rincon (Animas)	1940–1949	—	(<10,000)	W	(15,000–20,000)	W	—	North and McLemore (1986)	approximately $320,000 produced
Sylvanite	1902–1957	(6000)	(130,000)	(2500)	(35,000)	(80,000)	—	North and McLemore (1986)	—

malachite, azurite, and chrysocolla; a shipment in 1914 assayed 1.55% Cu and 68.5 ppm Ag (Wade, 1914).

In 1909, the Daisy mine (SW¼ sec. 33, T28S, R14W), a carbonate-hosted Pb-Zn replacement deposit, was shipping sorted oxidized ore that assayed 18% Cu, 617 ppm Ag, and 1–1.4 ppm Au. Total production from the Daisy mine is estimated to be <$10,000 (Strongin, 1957). The deposit consists of discontinuous fissure-filling veins and replacements (1.8–2 m wide) in brecciated U-Bar Limestone along northeast-trending faults. Chalcopyrite and pyrite occur in quartz-calcite veins; native bismuth and tenorite have been reported. Oxidized minerals include malachite, azurite, chrysocolla, jarosite, hematite, limonite, and pyrolusite (Strongin, 1957). A sample assayed 0.4% Cu, 22 ppm Mo, 850 ppm Pb, 625 ppm Zn, and 72 ppm Ag (Peterson, 1976).

The only production known from the Chapo mine (sec. 33, T28S, R14W) was in 1940 when some Cu-Au ore was shipped (Strongin, 1957). The deposit is in U-Bar Formation, but is at a lower stratigraphic interval than the Apache mine (Strongin, 1957). Quartz veins locally with lead, silver, and copper also cut andesite, basalt and rhyolite dikes (Strongin, 1957). Chloritic alteration is common. Samples from the Chapo mine assayed as high as 2.61% Cu, 5.95% Zn, 4.72% Pb, 0.3 ppm Au, 51 ppm Ag, and 0.004% Mo (NMBMMR file data). Two other mines in the district have reported assay data. A sample from the Luna mine assayed 2.0% Cu, 225 ppm Mo, 5.2% Pb, and 2.8% Zn; whereas a sample from the Summertime mine assayed 1.1% Cu, 66 ppm Mo, 200 ppm Pb, and 100 ppm Zn (Peterson, 1976). Gold assays from various pits range as high as 910 ppb Au (Griswold et al., 1989).

BIG HATCHET MOUNTAINS DISTRICT

The value of production from 1920 to 1931 in the Big Hatchet Mountains district is estimated as <$2000 (Table 2; Elston, 1965). Prospecting began in 1917, when gypsum and minor carbonate-hosted Pb-Zn (Ag) replacement deposits were discovered and one carload of Zn ore was shipped from the Sheridan mine. In 1919 a small lot was shipped from the Brock mine (Elston, 1963). Since then, the only known production has been several truck loads of agricultural-grade gypsum (50–80% $CaSO_4 \cdot 2H_2O$) in the 1950s and 1960s.

The Big Hatchet Mountains consist of faulted and tilted Paleozoic limestones and Cretaceous shales and sandstones that show little mineralization or alteration (Lindgren et al., 1910; Zeller, 1975; Drewes, 1991a, b). The Pb-Zn replacement deposits occur at the Sheridan mine in the northern part of the district, and at the Lead Queen mine in the southern part. At both mines, Pb-Zn-Ag oxide and sulfide minerals occur along bedding planes and faults in Horquilla Limestone. Smithsonite and galena also occur along a fault at the Sheridan mine. The fault zone is <1.2 m wide and was traced for 48.7 m underground. Samples assayed as high as 0.39% Cd, 16.6% Pb, 62 ppm, and 36.1% Zn (Scott, 1986; Drewes et al., 1988). The remaining resources at the Sheridan mine are estimated as 4500 st of material averaging 3.2% Pb, 13.7 ppm, and 2.2% Zn (Scott, 1986; Drewes et al., 1988). Samples from the Lead Queen mine assayed as high as 0.12% Cd, 0.01% Cu, 33.2% Pb, 253.7 ppm Ag, and 16.9% Zn. Three mineralized faults at the mine were estimated to contain 2900 st of material averaging 0.21% Pb, 38 ppm Ag, and 0.5% Zn (Drewes et al., 1988).

Gypsum at the Proverbial mine in Epitaph Dolomite is approximately 9 m thick and contains impurities such as anhydrite, clay, dolostone, limestone, and shale. Samples from the Proverbial mine contained 50–80% $CaSO_4 \cdot 2H_2O$. Weber and Kottlowski (1959) described deposits of Permian gypsum interbedded with dolostones exposed at the southwestern edge of the Big Hatchet Mountains (secs. 20, 21, 28, and 29, T31S, R15W). The gypsum deposits appear to be of high purity, but are too far from potential markets to be of commercial interest.

BROCKMAN DISTRICT

The Brockman district (sec. 1, T26S, R17W) consists of the Brockman silica quarries, operated by Phelps Dodge Corp., near Playas (Fig. 1). Silica sand worth less than $1 million has been produced from the Mojado Formation from the early 1900s until the 1990s for use as flux in nearby smelters.

FREMONT DISTRICT

The Fremont district in the northwestern Sierra Rica, at the junction of Luna and Hidalgo Counties, and Mexico (Fig. 1), discovered in 1860, has produced 190,000 lbs Pb, 10,000 oz Ag, 2000 lbs Cu, 10 oz Au, and 4000 lbs Zn from volcanic-epithermal vein and carbonate-hosted Pb-Zn replacment deposits (McLemore, *in press*; McLemore and Lueth, 1995, 1996). Most of this production has come from the International mine in Luna County with minor production from the Napone and Eagle mines.

Paleozoic carbonate rocks and Cretaceous clastic rocks are overlain by mid-Tertiary volcanic rocks and intruded by quartz monzonite and monzonite (27.0 ± 0.6 Ma, K-Ar, feldspar; Peterson, 1976; Deal et al., 1978) stocks (Strongin, 1957; van der Spray, 1970; Peterson, 1976; Griswold, 1961; Chuchla, 1981; Garcia-Esparza, 1988; Drewes, 1991b). Most of the volcanic rocks were mapped as the Chapo Formation (Peterson, 1976), but Bryan (1995) correlated the rhyolite ash flow tuffs to the Gillespie (32.7 Ma; $^{40}Ar/^{39}Ar$) and Oak Creek (33.5 Ma; $^{40}Ar/^{39}Ar$) tuffs. Rhyolite, latite, felsite, and lamprophyre dikes are common. The limestones are silicified and metamorphosed to marble and hornfels and the volcanic rocks exhibit argillic alteration.

The International mine has produced 879 st of ore since 1880 (Griswold, 1961). The best ore was a 10-st shipment grading 40% Pb and $62/st Ag (at $0.95/oz; Lindgren et al., 1910). Between 1910 and 1959, 14 railroad cars of approximately 50 st each and another 129 st

were shipped. Additional shipments probably were made, but not reported. The mine exploited a 1219-m long, 0.2–3-m wide volcanic-epithermal vein in a fault cutting Cretaceous sedimentary rocks (Griswold, 1961). The ore minerals are galena, sphalerite, and chalcopyrite accompanied by gold and silver and quartz, calcite, iron oxides, and pyrite as gangue.

The Napone (Napane, Nutshell) mine yielded several hundred tons of lead-zinc ore prior to 1949. In 1953, 9.23 st of ore were produced that contained 35.06 lbs of U_3O_8 (0.19% U_3O_8) and 3.69 lbs V_2O_5 (0.02% V_2O_5). En echelon replacement bodies and veins along bedding fractures and faults occur over approximately 213 m of brecciated and silicified limestone. Uranium minerals (carnotite, autunite) are sporadically distributed in ore bodies consisting of galena, cerussite, smithsonite, sphalerite, pyrite, chalcopyrite, calcite, siderite, and quartz. One selected sample contained 0.13% U_3O_8 and 127 ppm Th (McLemore, 1983) and May et al. (1981) reports one assay of 0.47% U_3O_8. Other assays range as high as 45.8% Pb, 30.8% Zn, and 35 ppm Ag (NMBMMR file data).

At the Eagle mine, replacement bodies and minor veins follow a fault striking N5°E in limestone (Elston, 1963). In the 1880s and in 1906–1907, the mine yielded 200 st of sorted galena that averaged 40% Pb and 685.8 ppm Ag (Lindgren et al., 1910). Galena with quartz and calcite has replaced limestone with little or no recrystallization. Sporadic tungsten and bismuth occur in the veins (NMBMMR file data).

GILLESPIE DISTRICT

The Gillespie (Red Hill) district, in the Animas Mountains, was discovered in 1880. A minor amount of gold, silver, copper, lead, and zinc, amounting to $100,000, was produced from volcanic-epithermal veins from 1880 to 1950 (Lasky and Wootton, 1933; Elston, 1965).

Oligocene volcanism and formation of major calderas dominated the geology in the Animas Mountains (Elston et al., 1979; Erb, 1979). The epithermal veins of the district lies in the ring-fracture zone of the Juniper and Animas calderas, the source of the Oak Creek Tuff and tuff of Black Bill Canyon, respectively (33.5, 33.6 Ma, Bryan, 1995). The exposed Animas (34.0 ± 0.1 Ma, $^{40}Ar/^{39}Ar$, feldspar, McLemore et. al., 1996a) and Walnut Wells porphyries (Zeller and Alper, 1965) and a buried quartz monzonite stock, located by drilling, are evidence of magma resurgence (Thompson et al., 1977; Elston et al., 1979). A major structural feature of the district, the Winkler anticline, appears to be draped above the ring-fracture intrusion discovered by drilling.

Four mineralogical types of volcanic-epithermal veins occur: silver (Gillespie mine), fluorspar (Winkler anticline deposits), oxidized lead-zinc (Red Hill), and manganese (Combined Minerals Corporation mine). Silicification is common near the veins. The largest mine in the district is the Red Hill mine (SW¼ sec. 30, T30S, R17W), where a northwest-trending, oxidized, quartz-calcite Pb-Ag vein cuts Oak Creek Tuff. The vein strikes N77°W, dips 75–85° NE, and consists of cerussite, minor anglesite, and minor galena, locally argentiferous. Malachite, chrysocolla, smithsonite, sphalerite, and wulfenite are also found in a gangue of quartz, calcite, and minor fluorite. Production exceeded 3750 st of ore containing more than 1 million lbs Pb and 14,250 oz Ag. Ore grades between 1905 and 1950 were 0.3 ppm Au, 139 ppm Ag, 0.18% Cu, 17.92% Pb, and 0.91% Zn. Workings consist of three shafts; one is 122 m deep with two levels. Dump and trench samples from the mine contained 45–80 ppm Ag, but insignificant gold.

The Gillespie deposit (W½ sec. 4, T31S, R18W), discovered in 1880, consists of shafts and numerous pits; the deepest is 30 m (Zeller and Alper, 1965). There was development work as late as 1991, but there has been no reported production. The Gillespie vein strikes N65°E, dips 65°NW, and cuts silicified Horquilla Limestone and calcareous siltstone of the Earp Formation. Azurite, malachite, and linnearite occur on the dump. Calcite, quartz, siderite, and minor fluorite are gangue minerals.

In 1960, fluorspar at the Athena (or Volcano) mine on the Winkler anticline was explored in N½ sec. 3, T31S, R18W. Several trenches and four shallow shafts were dug, 15–30 m deep percussion holes were drilled, and extensive sampling and geochemical testing were performed. From holes drilled in 1970–1971, the Texas Lime Co. delineated estimated reserves of 150,000 st of 25–35% fluorite (Scott, 1987), with copper and silver as potential byproducts. Subsequent development found that the fluorite veins were thin, discontinuous stringers, pods, and breccia cement and not large manto-type deposits. A mill was erected in sec. 34, T30S, R18W and 1500 st fluorite was shipped before 1977 (Phil Young, personal commun., April 19, 1994). However, the ore was low grade and difficult to concentrate, and the mill was unsuccessful. Jasperoids are common. Fluorspar occurs in a gangue of quartz and calcite, with local trace amounts of sulfides. Samples collected by De Jour Mines in 1987 and Madison Enterprises in 1996 from the silicified limestone contained 0.39–0.96 ppm Au and 5.2–6.5 ppm Ag. Small pits along the axis of the Winkler Anticline had very high silver in gossan locally (6450 ppm) and other samples ranged from a few ppm to 226 ppm Ag, with up to 0.58 ppm Au.

Between 1953 and 1957, approximately 1600 st Mn ore and jig-mill concentrates were produced from several veins in the district and shipped to Deming. Approximately 1500 st were from the Combined Minerals Corporation mill at the Ridge (Hodget) mine (SW¼ sec. 32, T29S, R18W), which contained 40–50% Mn, <6% Fe and 0.25% combined Cu, Pb, and Zn. The remainder of the production came from the Lucky mine (NE¼ sec. 30, T29S, R18W). There had been additional production from the Ridge mine during World War II and possibly World War I. The veins occur along normal faults in Oak Creek Tuff and Animas quartz monzonite that strike N14°E–N21°W, have steep dips, are typically <1 m wide and several hundred meters long. The veins at the Ridge mine consist of maganese oxides, calcite, barite, fluorite, and rare quartz and contained as much as 1.32% WO_3 and 39% Mn, but recovery of tungsten from manganese ore was not economically feasible (Dale and McKinney, 1959; Zeller and Alper, 1965; Williams, 1966; NMBMMR file data).

GRANITE GAP DISTRICT

The Granite Gap (San Simon) district, south-central Peloncillo Mountains, includes mines south of Blue Mountain and along Granite Gap (Fig. 1). Some reports consider Granite Gap, McGhee Peak, and Kimball as subdistricts of a larger San Simon district (Elston, 1965; Hudson, 1984; Smith, 1987), but North and McLemore (1986) considered them as separate districts because production was reported separately for each and each can be defined by geographic and geologic boundaries. For the purposes of this report, the three districts are considered separate districts.

Deposits in the Granite Gap district were first explored about 1887, and mining began in 1897 when control of the Granite Gap mines was consolidated (Gillerman, 1958). After 1915 mining operations were sporadic. Carbonate-hosted Pb-Zn replacement and skarn deposits are associated with Tertiary intrusions and occur in two geographic groups, those along the Preacher Mountain fault bounding the northern limit of the Granite Gap granite (Crystal mine) and those near the Granite Gap fault. The total value of production until 1906 was estimated as $600,000 (Lindgren et al., 1910). The Crystal mine was worked in 1954 and 1955. Total estimated production from the district amounts to $1.95 million, including more than 1.6 million lbs Pb and 91,052 oz Ag (Table 2). In addition, 3000 st of 0.5% WO_3 was produced in 1943, and 5 st of 6% Sb was produced in 1948 (Hobbs, 1965; Dasch, 1965).

In the Granite Gap district, Cretaceous and Paleozoic sedimentary rocks are exposed in fault-bounded blocks that are bordered by Proterozoic granite (Gillerman, 1958; Cargo, 1959; Armstrong et al., 1978; Gebben, 1978; Richter et al., 1990). These rocks have been intruded by the Granite Gap granite (33.2 Ma, $^{40}Ar/^{39}Ar$, McLemore et. al., 1996a), a quartz monzonite and a variety of dikes.

Vein deposits in the district occur mostly in limestone. In the skarns, limestone is replaced by calc-silicate minerals, mainly garnet, and minor amounts of quartz, calcite, epidote, and wollastonite (i.e., Crystal mine). Some zones contain 50–60% andradite garnet (Cargo, 1959) accompanied by galena, sphalerite, and chalcopyrite (Armstrong et al., 1978). Tungsten is present in several mines (Dale and McKinney, 1959). The primary ore minerals are sphalerite, galena, and chalcopyrite with minor

tetrahedrite in a gangue of quartz, calcite, pyrrhotite, barite, and pyrite. Silver occurs as matildite blebs in galena; selected samples assayed 3429–17,143 ppm Ag (Williams, 1966). Bismuth occurrs in arsenopyrite (Williams, 1966). Scheelite and molybdenite occur in some mines. At Granite Gap, the sulfides have been almost completely oxidized. Jasperiods are common. Skarn deposits developed near the intrusive bodies, and the carbonate-hosted Pb-Zn replacement deposits formed at lower temperatures farther from the intrusions (Armstrong et al., 1978; McLemore and Lueth, 1995, 1996).

Tungsten occurs with the base- and precious-metals locally, and was shipped from the Ward (Baker-Standard) mine (NW¼ sec. 26, T25S, R21W) (Cargo, 1959). Scheelite occurs in small pods and zones as much as 2 m wide in tactite at the mine. At the Sunrise mine, scheelite with Mo occurs in quartz veins in the granite and as disseminations in the garnet zone along the contact; assays as high as 0.58% WO_3 are reported (Dale and McKinney, 1959). Assays as high as 1.2% WO_3 are reported from the Buck Deer claims (Dale and McKinney, 1959). Fluorspar was found in pits in limestones of the Earp Formation in N½ sec. 21, T25S, R21W (Gillerman, 1958).

KIMBALL DISTRICT

The Kimball (Steins Pass) district, in the northern Peloncillo Mountains (Fig. 1) includes mines and prospects north of and immediately south of Steins Pass on I-10 (Elston, 1963). Elston (1963) places the Charles mine in the McGhee Peak district, but it is a volcanic-epithermal vein deposit similar to other mines in the Kimball district and is included in this district in this report. The volcanic-epithermal vein deposits were discovered in the area in 1875, and 400,000 oz Ag, 1500 oz Au, 125,000 lbs Pb, 12,000 lbs Cu, and some Zn were produced from 1883 to 1933 (Table 2). Most production was prior to 1910, but development continued until 1981. Some manganese was produced from the Black Face mine in the northern part of the district during World War II, where epithermal Mn veins occur in rhylite porphyry (Farnham, 1961). The veins are as much as 213 m long, strike N70°E, and dip 75°N to vertical.

The district is near rhyolite domes and flows that intruded volcanic and igneous intrusive rocks. Much of the district consists of tuff of Steins, erupted at about 34.4 Ma ($^{40}Ar/^{39}Ar$) from the Steins caldera (Fig. 1; Drewes and Thorman, 1980; Richter et al., 1990; Bryan, 1995). Most volcanic-epithermal veins are oxidized and controlled by fault zones within Upper Cretaceous or Tertiary volcanic rocks and consist of pyrite, chalcopyrite, galena, sphalerite, argentite, cerargyrite, and native gold (Lindgren et al., 1910; Lasky and Wootton, 1933; Elston, 1963). The vein systems of two principle mines, Volcano and Beck, are radial and concentric to the caldera margin.

The Volcano mine (sec. 17, T23S, R21W), largest mine in the district, produced several hundred thousand dollars worth of Ag ore before 1905 and shipped more than 4000 st between 1909 and 1947 (Richter and Lawrence, 1983). Shipments of 325 st in 1921 averaged 1320 ppm Ag and 3.3 ppm Au. Later shipments yielded lesser grades, 360 ppm Ag and 1.7 ppm Au in 1942 and 263 ppm Ag and 0.7 ppm Au in 1943 (Elston, 1963). The mine is on a northwest-trending vein system that is approximately 3200 m long and 15 m wide. Discontinous ore was found in quartz breccia. Above the 100 level, the ore was oxidized and enriched in cerargyrite. Samples collected by De Jour Mines near El Oro mine, south of the Volcano mine in 1987 contained as much as 3.2 ppm Au, 300 ppm Ag, >1000 ppm As, and 285 ppm Sb (M. L. Silberman, written commun., 2000).

South of the Volcano mine, on the Wyman claim, the Volcano vein is offset to the west by approximately 100 m and then splits into two east-dipping branches. At the Coyle and Sixty-six mines on the western split, andesite megabreccia is mineralized on the hanging wall and the footwall is in barren tuff of Steins. In 1934–35, the Sixty-six mine shipped about 545 st of ore with average assays of Ag 788 ppm and 3.8 ppm Au (Elston, 1963). At the El Oro and El Oro Value (Federal) claims, on the eastern split, vein walls are in andesite.

The Beck mine (sec. 31, T23S, R21W) was worked intermittently until 1936 and produced an unknown amount of Au-Ag ore. In 1980, the Beck property was developed for cyanide leaching (Enders, 1981). The deposit is in the ENE- to WNW-trending Beck vein, which extends for 914 m in andesitic rocks that have been cut by prominent dikes of monzonite porphyry (Enders, 1981; Richter and Lawrence, 1983). Argillic alteration is predominant. Ore minerals include cerargyrite, argentite, pyrargyrite, proustite, sphalerite, galena, chalcopyrite, bornite, and chalcocite with calcite, pyrite, clay, and quartz as gangue (Lindgren et al., 1910; Enders, 1981). Samples assayed as high as 36 ppm Au, 861 ppm Ag, 2.06% Cu, 0.33% Pb, 0.12% Zn, and low As (<300 ppb), Sb (<10 ppm), and Hg (<300 ppb) (Enders, 1981).

LORDSBURG DISTRICT

The Lordsburg district, in the Pyramid Mountains, is divided into the northern Virginia (Ralston, Shakespeare) and southern Pyramid (Leitendorf) subdistricts. The first claims were located on the polymetallic veins of the Pyramid subdistrict in 1870. After the Southern Pacific Railroad reached Lordsburg in 1880, mining began in the Virginia subdistrict (Huntington, 1947). Between 1904 and 1933, the Lordsburg district yielded more than 1.5 million st of Cu, Au, Ag, and Pb ore valued at approximately $19.5 million, mostly from the Eighty-five and Bonney-Miser's Chest mines (Lasky, 1938). Huntington (1947) reports that ore produced between 1904 and 1935 contained 2.58% Cu, 4 ppm Au, and 76.8 ppm Ag. Total production from the district has been over $60 million (Tables 1, 2) and acounts for more than 96% of total mineral production value reported for Hidalgo County from 1880 to 1974 (White, this volume). Placer gold has been reported (Johnson, 1972; McLemore, 1994) and 3527 st of fluorite were produced.

Host rocks in the district consist of Cretaceous andesite flows, which were intruded by plugs of basalt and rhyolite breccias and plugs. The volcanic rocks have been intruded by a Laramide granodiorite porphyry stock (58.81 ± 0.10, $^{40}Ar/^{39}Ar$, McLemore et al., this volume, p. 6) and related granodiorite porphyry and aplite dikes (Lasky, 1938; Thorman and Drewes, 1978; Elston et al., 1979, 1983).

Five sets of faults occur in the area: northeast, east-west, northwest, east-northeast, and north-south. They are, for the most part, pre-mineralization faults, which acted as channels for ore-forming solutions as well as sites of mineralization (Jones, 1907; Lasky, 1938; Clark, 1962, 1970). In general, the faults dip vertically. Veins are accompanied by argillic and propylitic alteration (Clark, 1962; Agezo and Norman, 1994).

Deposits in the district are Laramide base- and precious-metal, fissure-filling veins in fault and fracture zones that transect the contact zone of the granodiorite porphyry stock (Wells, 1909; Clark, 1970; Richter and Lawrence, 1983; McLemore et. al., 1996b). The vein deposits consist of quartz and pyrite and lesser amounts of base-metal sulfides, chiefly chalcopyrite, galena, and sphalerite. District zoning is prevalent (Clark, 1970). Fluid inclusion studies of some of the later veins indicate that the veins formed from 200–>300° C by acidic fluids (pH 4.5–6.0; Agezo and Norman, 1994). Gold assays from prospect pits range as high as 3100 ppb Au (Griswold et al., 1989). Granodiorite and andesite appear to be the most favorable host rocks. At least seven stages of brecciation occurred with six stages of mineralization (Lasky, 1938). Only the second stage of mineralization yielded economic deposits. Three major ore types were recognized; (1) Cu-tourmaline fluxing ores (Eight-five mine), (2) Cu-specularite milling ore (Banner mine), and (3) manganosiderite-Ag veins. Ore minerals include chalcopyrite, galena, and sphalerite in a gangue of tourmaline, calcite, specularite, barite, sericite, manganosiderite, and fluorite. Oxidation and secondary enrichment occurred at variable depths (Lasky, 1936). In some places, sulfides were found near the surface (Huntington, 1947).

Two principal producing mines in the district, the Eighty-five and Bonney mines, are on northeast-trending faults and were mined over a strike length of 1326 m and a depth of nearly 610 m (Clark, 1962, 1970). Ore at the Eighty-five mine was found chiefly within or in contact with granodiorite, while the Bonney, Henry Clay, Atwood, and numerous others mines were in andesite (Lasky, 1938; Clark, 1970). The Eighty-five groups of claims produced nearly 90% of the ore from 1904 to 1935. This production, however, was dependent almost entirely on

demand from copper smelters for siliceous-fluxing ore to reduce the melting point of the copper ore. Mining activity was suspended when, in 1931, this demand ended. The ore at the Eighty-five mine came from the Emerald vein, which was mined for a continuous length of about 610 m and to a depth of 600 m and produced approximately 1.4 million st of ore that averaged 2.8% Cu, 42 ppm Ag, and 3.8 ppm Au (Lasky, 1938).

The Banner Mining Co. operated two mines, the Bonney and Miser's Chest shafts. By 1943, the Bonney mine had been developed to a depth of 442 m and for 610 m along strike. The vein ranged from 1.2 m to 6.1 m wide (Huntington, 1947). At that time, the Bonney mine was the principal producing mine in the district, having maintained an annual production rate of 3000 st per year for several years (Huntington, 1947). The Bonney vein strikes for more than 914 m on the surface at N50°E, dips steeply northwest, averaged 2.6% Cu, and is 304 m from the granodiorite contact. Drilling showed that the amount of Au and Ag decreased rapidly with depth, and the amount of silica gangue decreased from 75% in the upper levels to 45% at the 457-m level. Between 1910 and 1940, the Atwood group, which includes the Atwood and Henry Clay mines, produced 36,630 st of ore containing 3330 oz Au, 136,364 oz Ag, 706 tons Cu, and 115 st Pb (Huntington, 1947).

Fluorite occurs in lenticular veins in the Pyramid subdistrict (Williams, 1966; McAnulty, 1978). The veins occur in a zone 1.7 km long and <1.2 m wide, and consist of fluorite, calcite, and quartz. Production averaged 60% CaF_2 (Williams, 1966). Fluorite from the area had fluid inclusion homogenization temperatures of 142–174°C and salinities <1.4 eq. wt.% NaCl with no evidence of boiling (Elston et al., 1983; Hill, 1994).

Approximately 5000 st of perlite were mined from three quarries in the southern part of the district in 1952–1954. However, the presence of worthless stony rhyolite within the perlite deposits made production uneconomic (Flege, 1959). In the Leitendorf Hills perlite mine, perlite occurs as irregular lenses and seams of devitrified glass and alteration products in a rhyolite dome.

McGHEE PEAK DISTRICT

The McGhee Peak district, in the central Peloncillo Mountains between Granite Gap and Kimball districts (Fig. 1) includes the abandoned mining camp of McGheeville. Mineralized skarns were first identified in the district in 1894, but it was not until 1904 that the McGhee family acquired the mining rights to the area (Don McGhee, personal commun., 1994). Carbonate-hosted Pb-Zn replacement and skarn deposits yielded 12 million lbs Pb, 10 million lbs Zn, 85,000 lbs Cu, 100 oz Au, and 200,000 oz Ag (Table 2). Drilling in the early 1990s located a low-grade porphyry copper deposit buried in the northwestern part of the district.

Of the several mines and prospects in the district, the Carbonate Hill (McGhee) mine was the largest in production. In June 1948, a fire destroyed the head frame, shaft timbers, and surface buildings (Anderson, 1957). Approximately 91% of the value of the reported production was from Pb and Zn; 9% was from Ag. Approximately 100,000 st of ore and waste were produced; the ore averaged 6% Pb, 5–6.5% Zn, and 34–68 ppm Ag (Gillerman, 1958; Richter and Lawrence, 1983; Don McGhee, personal commun., 1994).

The central Peloncillo Mountains consist of faulted Proterozoic to mid-Tertiary extrusive and intrusive igneous rocks and sedimentary rocks (Armstrong et al., 1978). Paleozoic carbonate rocks and Mesozoic clastic rocks underlie most of the mountains. The sedimentary rocks and Proterozoic granite are intruded and metamorphosed by a number of igneous rocks. Granite porphyry dikes and sills were intruded 29.8 ± 0.9 to 32.5 ± 1.0 Ma (biotite, K-feldspar, K-Ar; Hoggat et al., 1977; Armstrong et al., 1978). Fine-grained porphyritic to felsic rhyolite dikes that are probably related to the granite porphyry were intruded and were followed by intrusion of quartz-latite porphyry dikes and sills at 27 ± 0.8 to 25.8 ± 0.8 Ma (biotite, plagioclase, K-Ar; Hoggat et al., 1977).

Many small, Pb-Zn-Cu-Ag skarn and carbonate-replacement deposits occur adjacent to dikes and sills, but only four mines, Johnny Bull, Silver Hill, Carbonate Hill, and Crystal mines, had significant production. Deposits adjacent to intrusive rocks tend to be skarns with calc-silicate gangue mineralogy. Calc-silcate minerals are absent in the distal deposits, which are typical of carbonate-hosted replacement deposits.

The Carbonate Hill mine (SE¼ sec. 34, T24S, R21W) was staked in 1894 and acquired in 1916 by the McGhee family. A dike there, 6–9 m wide at the shaft but wider toward the northwest, follows a northwest-trending fault. On its southwest side, epidotized Still Ridge Formation is sparsely mineralized and Gillerman (1958) estimated the depth to potentially favorable Carbonate Hill Limestone to be approximately 150 m. The deposit contains local skarn minerals (such as epidote, garnet, and wollastonite), but most of the ore is sulfide-replacements in Horquilla Limestone. Ore minerals include galena, cerussite, argentiferous galena, sphalerite, smithsonite, and chalcopyrite in a gangue of quartz, calcite, and garnet. Workings consist of a 183-m-deep shaft containing approximately 731 m of drifts, a short adit, and several shallow shafts and pits. The McGhees worked the mine in 1924–1930 and 1937. A flotation mill was built in 1927; in 1929 J. H. Parker reported that it processed 35 short tons per day (stpd). The mill was reconditioned to 75 stpd while leased to New Mexico Western Mining Co. in 1940. Shattuck-Denn Mining Co. did exploratory drilling in 1942 and in 1943 shipped 742 st of ore to its mill in Bisbee, Arizona. D. McGhee resumed mining in 1947 until the fire in 1948 and only small shipments were made in 1949–50. According to Mr. McGhee (personal commun., 1959) approximately 90,000 st of ore and waste had been removed by all operators. The grade, estimated by Gillerman (1958) as Pb 6%. Zn 5%, and Ag 2 oz/ton, agrees with the grade of the 1943 Shattuck-Denn shipment of 6.6% Pb, 4.5% Zn, and 41 ppm Ag.

At the Crystal mine (NW¼ sec. 19, T25S, R20W) pockets of galena, sphalerite, and minor chalcopyrite occur in garnet-tremolite-epidote skarn that replaces Escabrosa Limestone along a N15°E fault traced from a body of quartz monzonite porphyry for 300 m (Cargo, 1959). In 1941, 2200 st of ore treated at the Carbonate Hill mill yielded two carloads of concentrate containing 140,000 lbs Pb, 68,000 lbs Zn, 1000 lbs Cu, and 1.191 oz Ag, valued at $14,068. A carload of picked ore stockpiled at the mine in 1959 assayed Pb 12%, Zn 12%, and 102.8–171.4 ppm Ag (James Sweet, personal commun., 1959).

The mines and prospects on the west side of the range are arranged in successive elongated Cu, Zn, Pb-Zn and Pb-Ag zones around the northwest-trending Johnny Bull fault (Elston, 1963; Smith, 1987). Andesite dikes intruded along the fault. Wollastonite and green andradite-grossularite garnet skarns occur at intersections of dikes and permeable carbonate beds, especially at junctions of two dikes. Sulfide grains are scattered through the skarn and ore pockets developed at intersections of cross fractures and the "marble line," the contact between skarn and limestone recrystallized to marble. The Johnny Bull mine (secs. 3, 4, T25S, R21W) is in the central copper zone and produced a considerable tonnage of copper ore prior to 1910 (Gillerman, 1958). Chalcopyrite, azurite, malachite, galena, bornite, and chrysocolla are ore minerals, in a gangue of garnet, calcite, quartz, pyroxene, epidote, and wollastonite. The mine consists of two inclined shafts; the deeper of which reachs a depth of 46 m. The Johnny Bull mine was reclaimed by 1958.

The Pb-Zn-Ag Silver Hill deposit (sec. 3, T25S, R20W) is controlled by the junction of two bleached dikes, striking N40°E and N20°W. According to J. H. Parker, the largest ore body measured 2 m wide, 6–9 m long and 60 m deep but most pockets were only 0.6–1.0 m wide and yielded approximately 200 st. The Silver Hill claim was staked in 1906; peak activity was in 1917–18, 1927–30 and 1942–52. Shipments were approximately 6300 st of picked sulfide ore with 10–20% combined Pb and Zn (Pb:Zn = 2–4) and 51–68 ppm Ag, valued at about $230,000.

Drilling in the early 1970s and 1990s located a subeconomic porphyry copper deposit at a depth of 30 m in the northwestern part of the district (NMBMMR file data). Cyprus Minerals Corp. filed claims in sec. 30 and 31, T24S, R21W in the early 1990s. Pyritization and argillic alteration occurs in most drill holes. Phyllic alteration is exposed in a small outcrop near the drill sites (Hudson, 1984).

MUIR DISTRICT

The Muir district, in the southern Pyramid Mountains (Fig. 1) includes fluorite and volcanic-epithermal veins that have been previ-

ously included in the Lordsburg, Animas, or Rincon districts by some geologists. Fire clay and perlite deposits also are present. Past production and known resources in the Muir district are generally small, but the district has not been extensively explored. Approximately 100 oz Ag have been produced from the Silver Tree mine (Rex Kipp, personal commun., 1959), and $40,000–60,000 worth of fluorite has been produced from the Doubtful (Animas) mine, including 9175 st of 60% CaF_2 between 1942 and 1953. Approximately 5000 st of perlite were shipped from the northern part of the district in 1952–1953.

The district is in the ring-fracture zone of the Muir caldera (Deal et al., 1978; Elston et al., 1983; Elston, 1994). Pre-caldera rocks consist of Pennsylvanian and Cretaceous sedimentary rocks, Upper Cretaceous and/or lower Tertiary basalt and andesite, and Oligocene andesite (Elston et al., 1983; Elston, 1983). The tuff of Woodhaul Canyon has been dated as 35.3 Ma ($^{40}Ar/^{39}Ar$; Bryan, 1995) and approximates the age of the caldera. Numerous diorite, monzonite, andesite, and rhyolite dikes and small stocks intruded the caldera and older rocks (Elston et al., 1983). One andesite stock has an age of 29.4 ± 0.7 Ma (whole rock, K-Ar; Elston et al., 1983).

In the Pyramid Mountains, hyrdothermal mineralization and alteration occurred during collapse of the Muir caldera in Oligocene time and again during Miocene or younger time via hot springs and shallow vein-forming hydrothermal fluids (Elston et al., 1983). The Oligocene alteration is widespread, but is unrelated to present thermal activity along the Animas Valley fault (see Day 1 road log). Veins of several ages and mineral assemblages are scattered throughout the district. They are fault- and fracture-controlled, and are associated with argillic alteration characterized by chlorite, pyrite, and quartz. Fluorite was found in drill cuttings at the Cockrell Corp. No. 1 Federal well in sec. 21, T24S, R19W, indicating mineralization of Recent age (Elston et al., 1983).

Fluorspar deposits at the Doubtful vein, are unrelated to the adjacent porphyry (Elston, 1994). In 1954, the mine was purchased by General Chemical Corp. after a drilling program and held for future reserves (W. A. Ballard and Don Still, personal commun., 1959). The deposit is 1.2–3.0 m wide and 500 m long in andesite and occurs in a fissure vein that strikes N20°W and dips 80°SW (Elston, 1994). Green and white, fine-grained to coarsely crystalline fluorite is interwoven with finely crystalline white quartz, Mn oxides, and manganiferous calcite. The fluorite fills a series of nearly vertical veinlets and cements breccia along the veins. In 1942–1943 and 1952 the Doubtful mine produced 4600 st of 63% CaF_2. A grab sample of stockpiled material contained 43.0% CaF_2, 28.6% SiO_2, and 19.5% $CaCO_3$ (Williams, 1966). Fluid inclusion studies indicate temperatures of homgenization of 137–349°C with evidence of boiling; salinities were below 9.47 eq. wt.% NaCl (Elston et al., 1983; Hill, 1994). The age of mineralization is most likely Miocene or younger (Elston et al., 1983).

Volcanic-epithermal veins at the Silver Tree and Allen mines occur in andesite of Holtkamp Canyon and tuff of Woodhaul Canyon (Elston et al., 1983). The veins consist of pyrite, quartz, galena with Ag, and stibnite. Additional volcanic-epithermal veins occur in the area.

PRATT DISTRICT

The Pratt district (secs. 29, 32, 33, T27S, R20W) consists of a quarry in shale and clay, south of Pratt (Fig. 1). It has been mined sporadically since 1902 for use as refractory material in the nearby copper smelters. Production since 1902 is estimated as $150,000–200,000. The district is complexly faulted and contains altered Paleozoic limestones and Cretaceous sedimentary rocks that are overlain by volcanic rocks. Minor fluorite and manganese veins (Bluebird, NE¼ sec. 12, T27S, R21W, Black Streak, sec. 17, T27S, R20W), approximately 32 cm wide, cut the andesite. Approximately 19 st of 29.5% Mn were produced from the Black Streak mine in 1954. Samples collected by W. E. Elston in 1959 contained 3.0% W. A sample of quartz-agate veinlets (7.5 cm wide) in rhyolite breccia reportedly contained 52.8 ppm Au (W. A. Ballard, personal commun., 1959).

RINCON DISTRICT

The Rincon (Animas) district, in the northern Animas Mountains (Fig. 1) contains carbonate-hosted Pb-Zn replacement, volcanic-epithermal, and carbonate-hosted Mn replacement deposits. Prospecting began in the area in 1880. Production has been minor and amounts to approximately $320,000 worth of Cu, Ag, Au, and Pb (Table 2).

The oldest rocks in the northern Animas Mountains consist of Proterozoic granite (1200 Ma, Soulé, 1972; Drewes, 1986). Paleozoic marine and Cretaceous clastic sedimentary rocks overlies the granite. Tertiary post-orogenic intrusive and volcanic rocks are the youngest rocks in the district. One of these intrusions is a quartz-monzonite porphyry that has been dated as 34.0 ± 0.1 Ma (K-feldspar, $^{40}Ar/^{39}Ar$; McLemore et. al., 1996a).

The Rincon mine (NW¼ sec. 31, T29S, R19W) is a carbonate-hosted Pb-Zn replacement deposit hosted by Horquilla Limestone southeast of a northeast-trending strike-slip fault. The jasperized limestone is 1.2–1.8 m thick, brecciated and folded, and occurs below a gray–black shale along the intersections of two fault zones that strike N45°W, dips 56°NE and N80°E, dips 56°NW (Elston, 1963). Ore minerals include galena, chalcopyrite, sphalerite, and hemimorphite. In 1940 and 1947–1949, approximately 850 st of siliceous flux containing 15,000–20,000 oz Ag were shipped to the Douglas smelter in Arizona (Lewis Croom, personal commun., 1959).

The Fredingbloom, Zinc, and White Rose mines occur along a ridge of Escabrosa Limestone where replacement ore deposits occur at or along brecciated fault zones and north-trending rhyolite dikes. Smithsonite and anglesite are predominant minerals at the Fredingbloom and Zinc mines, whereas barite, galena, and sphalerite are predominant minerals at the White Rose mine (Elston, 1963). Chrysocolla present at the Zinc mine. A sample from the Zinc mine assayed 35% Pb and 14% Zn (Elston, 1963). In 1910, 13 carloads of Ag ore (worth $10,000) were shipped from the Fredingbloom mine, and in 1948–1949, production from the Zinc mine amounted to a few additional carloads (Lewis Croom, personal commun., 1959).

The Cowboy mine is in a volcanic-epithermal vein in the Red Hill rhyolite. Quartz veins occur in a zone <1 m wide and <5 m long. Quartz with trace amounts of pyrite and gold occur in the veins (Elston, 1963).

Additional carbonate-hosted Pb-Zn replacement and volcanic-epithermal vein deposits are scattered throughout the district, but none have yielded large amounts of ore. These deposits are typically small and similar to those described above. Small carbonate-hosted Mn replacement deposits occur along faults and fractures within Paleozoic carbonate rocks at the Blacktop No. 1 claim. A grab sample of ore assayed 28.55% Mn, 0.27% Cu, 0.50% Pb, and 0.26% Zn (Elston, 1963).

SILVER TIP DISTRICT

The Silver Tip district, in the southern Peloncillo Mountains (Fig. 1), is named for the Silver Tip mine, a volcanic-epithermal vein deposit, located in Arizona (sec. 25, T22S, R32E, Arizona baseline). The Silver Tip mine consists of a 73-m adit and a 9-m shaft (Hayes et al., 1983). Total production is unknown. There is no production from New Mexico. Additional prospects occur along the altered Silver Tip vein. North of the district a small abandoned rock quarry remains where rhyolite tuff was quarried for local use as building stone.

The district lies within the Geronimo Trail caldera, source of the Gillespie Tuff. Rocks in the district are ash-flow tuffs, volcanic breccia and epiclastic sedimentary breccias, rhyolite dikes and domes, and andesite to dacite lavas (Deal et al., 1978; Erb, 1979; Hayes, 1982; Hayes and Brown, 1984; K. M. Emanuel [unpubl. report for Nicor Mineral Ventures, 1985, NMBMMR archives]; McIntyre, 1988).

The Silver Tip mine and several nearby prospects are located near the New Mexico part of the district in an area of argillic and advanced-argillic altered rocks that extends for about 805 m into New Mexico (K.M. Emanuel, unpubl. report, 1985; McIntyre, 1988). The deposit is in a 0.2–3-m-thick, 457-m-long mineralized fault zone, which is part of the Geronimo Trail caldera ring-fracture zone. Pyrite is common and bromargyrite (AgBr) has been identified at the Silver Tip mine. Rock chip samples collected by Nicor Industries, Inc. are typically low and contain as high as 0.62 ppm Au, 8.5 ppm Ag, 225 ppm Cu, 490 ppm Pb, 1350 ppm Zn, and 235 ppm Mo (K.M. Emanuel, unpubl. report, 1985).

Previous studies of the area include a 1980 mineral-resource survey of the Bunk Robinson Peak and Whitmire Canyon Roadless Areas (Hayes, 1982; Hayes et al., 1983; Watts et al., 1983; Hayes and Brown, 1984), which identified a zone of altered rocks having probable mineral potential for Ag, Au, Bi, Mo, Pb, and Zn. This zone forms the southern contact of a dacitic lava flow in the northern part of the district and consists of argillically altered rocks and anomalous As, Ba, Mo, and Pb in stream-sediment samples (Watts et al., 1983). The quartz veins, with local pyrite, in the zone strike N10°W–N15°E, are up to 6 m thick, and steeply dipping (McIntyre, 1988). In the mid-1980s, a drilling program was conducted by Nicor Industries, Inc., but no reserves were found.

SYLVANITE DISTRICT

The Sylvanite district, south of the Eureka district (McLemore, this volume, p. 21) in the Little Hatchet Mountains (Fig. 1), is included with the Eureka district in some reports to form the Hachita district (Anderson, 1957; Johnson, 1972). The Hachita district name is no longer in use. Skarn, vein, and placer deposits occur in the district and production is estimated as 2500 oz Au, 130,000 lbs Cu, and 80,000 lbs Pb (Table 1). In the southern portion of the district, 5632 st of scheelite-garnet ore grading 0.44% WO_3 were produced from a skarn (Dale and McKinney, 1959). A carload of arsenic was produced in 1924 (Dasch, 1965).

Copper was discovered near the old mining town of Sylvanite in the 1880s (Lindgren et al., 1910). In 1908, a worker at the Wake Up Charlie claims discovered placer gold and tetradymite (Bi_2Te_2S) in a small gulch east of Cottonwood Spring (Lasky, 1947). The tetradymite was mis-identified as the mineral sylvanite, a gold telluride, which the prospector had seen at Cripple Creek. This led to the naming of the Sylvanite mining camp and to a gold rush (Jones, 1908a, b; Dinsmore, 1908; Martin, 1908).

In the 1960s through 1990s, several companies have examined the area for potential metal deposits. Exxon Corp. drilled 10 holes (9100 m total footage) in the 1960s–1970s. Phelps Dodge, Inc., also examined the area. In 1990, Champion Resources, Inc., drilled 27 holes (3600 m) and in 1991–1993, Challenger Gold joint ventured with Champion Resources and drilled 7 additional holes. The results were not encouraging, although drilling did intercept 10 m that assayed 2 ppm Au.

The oldest rocks in the district occur at the southern end of the mountains and in isolated hills, where Proterozoic(?) granite has been cut by northeast-trending aplite dikes (Lasky, 1947; Zeller, 1970). The younger rocks in the district include Paleozoic and Mesozoic sedimentary rocks and Tertiary volcanics (Zeller, 1970; Lawton et al., 1993). Cretaceous sedimentary formations make up the bulk of the Little Hatchet Mountains. The Hidalgo Formation consists of volcanic rocks that rests unconformably upon the older sedimentary formations; a hornblende andesite at the base of the section has an age of 71.44 ± 0.19 Ma ($^{40}Ar/^{39}Ar$, hornblende; Lawton et al., 1993). The upper part of the volcanic rocks is truncated by a thrust fault. Middle-to-upper Tertiary volcanic rocks consist chiefly of rhyolite and latite, and rest with angular unconformity on the older rocks.

In the Little Hatchet Mountains, several Laramide-age stocks, dikes, and sills have intruded the Cretaceous sedimentary rocks, and the most highly mineralized areas are associated with these intrusions. The intrusion in the Sylvanite district is called the Sylvanite quartz-monzonite stock (Zeller, 1970) and the intrusion in the Eureka district to the north is the Eureka stock. The youngest intusive rock appears to be the granite at Granite Pass, for which $^{40}Ar/^{39}Ar$ dating of K-feldspar yielded a plateau age of 32.33 ± 0.18 Ma (Channell et al., this volume). Rhyolite, felsite, and latite dikes have intruded the granite.

Four types of deposits occur in the district: Laramide veins, skarns, disseminated pyrite in Tertiary intusive rocks, and placer gold deposits. Lasky (1947) described 10 different mineralogical associations: (1) disseminated pyrite in Tertiary intrusive rocks, (2) chalcopyrite skarns (Copper Dick mine), (3) pyrrhotite replacements (Clemmie mine), (4) chalcopyrite-tourmaline veins (Buckhorn mine), (5) arsenopyrite-tourmaline veins (Creeper mine), (6) tetradymite-native gold veins (Gold Hill mine), (7) chalcopyrite-barite veins (Santa Maria mine), (8) galena veins (Silver Trail mine), (9) quartz-pyrite-chalcopyrite veins (Broken Jug mine), and (10) fluorite-calcite-quartz veins.

Gold in the district chiefly occurs in quartz fissure-veins in the Sylvanite stock and adjacent limestone (Anderson, 1957). The veins typically consist of quartz cutting and replacing altered host rocks (Lasky, 1947). Tourmaline occurs in the altered rocks, and actinolite and chlorite occur in pockets. Tetradymite is the most abundant Au-bearing mineral. The veins are typically short, erratic, steeply dipping, pinch and swell, and <3 m wide. Samples from some of the earliest production reportedly assayed 7406–10,286 ppm Au (Martin, 1908).

The Eagle Point, Cactus Group, and Copper Dick mines are examples of the skarn deposits. A small amount of scheelite was produced from the Eagle Point tungsten claims in 1943 (650 st of 0.44% WO_3; Dale and McKinney, 1959). The last ore shipment reported was in the early 1950s from the Hornet mine (Anderson, 1957). A small W skarn occurs in a garnetiferous zone along the contact between Horquilla Limestone and Tertiary intrusive rocks at the Eagle Point claims in the southern tip of the area (Dale and McKinney, 1959; McLemore et. al., 1996b; see Day 2 road log, stop 3). The contacts between W-Pb-Cu skarns with the limestone are irregular, but sharp. Another small Mo-W-bearing skarn occurs in a garnetiferous zone in Howells Ridge Formation (now the U-Bar Limestone) at the Cactus Group claims (Dale and McKinney, 1959).

The Copper Dick mine, discovered in the 1890s, is a Cu-garnet skarn deposit at the intersection of the Copper Dick fault with a lamprophyre dike that produced Cu, Ag, Au, and Pb from at least 1905–1954. Calc-silicate skarn-type minerals such as epidote, chlorite, and actinolite are present as gangue minerals. A small Bi anomaly was discovered by Challenger Resources in the southern part of the district, which may be related to Pb-Zn and/or Au skarns. Samples collected from the Copper Dick mine contained 2–6% Cu, up to 1.4 ppm Au, 13–37 ppm Ag, <1–19 ppm Pb and 8–198 ppm Zn (M. L. Silberman, written communication, 2000). Samples collected from the Badger group of claims, west of the Copper Dick mine contained 1–6% Cu, 0.2–8.2 ppm Au, 4–992 ppm Ag, 72–1880 ppm Zn, and 2–140 ppm Pb (M. L. Silberman, written communication, 2000).

The Buckhorn mine is in metamorphosed limestone beds near the Sylvanite stock at the west end of a vein outcrop that strikes S70°E and dips 70–90° NE (Lasky, 1947). The vein averages 1.2–1.8 m wide, and lies between a lamprophyre dike and garnetized beds of metasediments. In some places, clay gouge and breccia occur along the vein. Native gold, silver, chalcopyrite, sphalerite, bismutite, and tellurobismuthite are ore minerals, and quartz, calcite, tourmaline, limonite, pyrite, and chlorite are gangue minerals.

At the Green mine, gold occurs in a pinch-and-swell vein in limestone-clast conglomerate and garnet near quartz monzonite of the Sylvanite stock and dikes. The most abundant metallic ore mineral is tetradymite (Lasky, 1947). Visible gold occurs as grains and thin streaks in the quartz. The Ag-Au ratio at the Green mine was about 1.5–2 times as much Ag as Au; much of the silver occurred in hessite. Chemical analyses of selected samples from the Sylvanite district are in McLemore et al. (1996b).

Zones of disseminated pyrite occur in the monzonite near Cottonwood Spring. The monzonite is altered to jarosite, iron oxides, and pyrite. Unaltered, pre-ore lamprophyre dikes cut the altered monzonite, suggesting that the alteration is older than the mineralization (Lasky, 1947).

The placer gold deposits were mined by hand using simple techniques and implements. Dry washers and rockers were employed in concentrating the gold because of the shortage of water (Lindgren et al., 1910). The placers were not extensive, and by March 1908, they had been abandoned. Total placer production was estimated to be <200 oz, worth between $2000 and $3500. The short duration of the gold rush is reflected in the history of the town of Sylvanite which was established in 1908 and had an average population that year of 500 to 1000. By 1909, with abandonment of the placers, the population had dropped to 70. Placer gold can still be found in some of the arroyos.

ACKNOWLEDGMENTS

This paper is part of a study of the mineral resources of the Mimbres

Resource Area (Doña Ana, Luna, Hidalgo, and Grant Counties), in cooperation with the U.S. Geological Survey and U.S. Bureau of Land Management. Susan Bartsch-Winkler, David Sutphin, James McLemore, and Chuck O'Donnell are acknowledged for field assistance, discussions, and providing data. Sherman Marsh, Bill McIntosh and M. L. Silberman reviewed an earlier draft of this manuscript and their comments are appreciated. Daniel Hack and Tim Pease provided additional technical assistance. This work is part of ongoing research of mineral resources in New Mexico at NMBMMR, Peter Scholle, Director and State Geologist.

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